MEXICAN GEMS

KUNZ

SUBJECT TO REVISION.

[TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.]

Vol. 32, pp. 55-93, 1902

Gems and Precious Stones of Mexico.

BY GEORGE FREDERICK KUNZ, NEW YORK CITY.

(Mexican Meeting, November, 1901.)

MEXICO has been famous for its silver-mines ever since the Spanish conquest; but in respect to gems, although many varieties occur, yet only a few have been obtained in any important amount. Considering the extent of country in Mexico and in the adjoining States of the Central American Republics, and the richness of mineral wealth that must surely exist there, our present knowledge of the occurrence of precious stones is remarkably small. The great prevalence of igneous rocks would lead us to anticipate the future discovery of many localities of gems and ornamental stones, when fuller scientific exploration shall have taken place.*

At the present time the only gem-stone that is systematically mined in Mexico is opal, and the only important ornamental stone is *tecali*, the so-called Mexican onyx. In addition to these may be mentioned the pink garnet, or rosolite, found in one locality in the State of Morelos, where it is worked to some extent, and the pyrope or Bohemian garnet, weathered out of igneous rocks, and gathered by the Comanche Indians in Chihuahua, as those of Arizona and New Mexico are collected by Navajoes. Other garnet-localities are known, but have not been developed. Topaz, which occurs in some places, will be mentioned later. Moreover, beautiful amethysts from Guanajuato are well known; but while making superb specimens for the mineral cabinet, they rarely afford material for cutting.

Great interest attaches to certain semi-precious stones, used and highly valued in pre-Columbian Aztec times, of which the localities have been lost, or but recently rediscovered. Prominent among these is the precious and even sacred *Chalchihuitl* of the Aztecs, at one time supposed to be turquoise, but now more

* See *Gems and Precious Stones of North America*. By George F. Kunz, New York, 1892, pp. 275–309.

correctly identified with jade. Recent studies of the sources of this remarkable stone are cited below. Another is a fine amethyst, different from that of Guanajuato, which was worked into ornaments by the ancient natives. A third stone, used to a great extent by the Aztecs, is obsidian, or volcanic glass. The wonderful chipping and lapidary skill shown in their work on this material in Mexico has never been equalled elsewhere. The principal locality where this obsidian was mined is known, and has recently been described in detail; but there were doubtless other localities, since there are several varieties of the product.

Of the rarer gems, diamonds, ruby, sapphire and emeralds, few occurrences are reported, and no deposits are mined; reliable information about them is limited. Santiago Ramirez, in a work on the minerals of Mexico,* relates, on the authority of another person, that in the Mexican war of independence, Gen. Vicenzo Guerrero, while selecting a camping-place for his men in the State which now bears his name, but at a point not named, found some diamonds. Their mode of occurrence, however, as described, makes it almost certain that they were only brilliant crystals of quartz. They are described as having been found loose in the interior of large hollow pebbles, and were, in other words, geodes. Some of them are said to have been set in earrings, and to have been pronounced octahedral diamonds; and others were purchased by a lapidary at the capital. The accounts are vague; but one specimen, of three carats, is said to have been presented by Gen. Guerrero to the museum of the Mexican College of Mines. If this crystal could be found and identified, there would be a clear understanding of the facts.

Ruby has never been positively found, though it has been reported from Durango, and at one or two other points. It is not at all certain, however, that these specimens were not pyrope garnets. A single rolled pebble of blue and white mottled corundum is the nearest approach to sapphire yet obtained. It occurred among pebbles of agate and chalcedony, and was brought from near San Geronimo, Oaxaca, by Dr. Knight Neftel, of New York, and identified by the writer.

---

* *Noticia Historica de las Mineras de Mexico.*

Emerald, or perhaps only a finely-colored beryl, is reported from three points—the hill of Cerro Gordo, in Guanajuato; Tejupilco, in the State of Hidalgo, near Tulancingo, where it is found in mica schist; and a locality in the State of Guerrero, from which a few small specimens of good color, but imperfect, are in the *Escuela Minera Nacional*, at the City of Mexico.

Garnet.—The occurrence of choice pyrope garnets in Chihuahua, near Lake Yaco, has already been mentioned. Fine ones are also reported from Sonora. They exist, doubtless, in many other localities in these portions of Mexico; for these garnets occur at various points in Arizona and New Mexico, and have been called "Arizona rubies." Another locality, at Triunfo, in Lower California, yields small bright crystals, evidently almandite, in a white granite. These are not pyrope, which occur in rounded nodular forms, in strictly igneous rocks. One or two other points are reported, but none of any importance.

Much the most interesting development of garnet in Mexico is at Xalostoc, in the State of Morelos.* Here the very perfect crystals have been found, dodecahedral in form, and up to a full inch in diameter. They are of a fine purplish pink color, imbedded in a matrix of white limestone, with olive-green vesuvianite. Analysis proves these crystals to be a variety of grossularite; but their color is so peculiar among garnets that the name *rosolite* has been proposed, and to some extent adopted for them. The crystals are not transparent, and hence are not suitable for cutting as gems, though very attractive as specimens. The white or pale-gray rock, however, studded with the embedded pink garnets and yellow-green vesuvianite, makes a beautiful ornamental stone, and has been employed as such. Polished slabs and small columns of this "rose-garnet" rock may be seen in the principal museums of the United States, notably a fireplace and mantel in the American Museum of Natural History, New York City.

Four species of the garnet-group have thus been definitely recognized from Mexico: pyrope, or Bohemian garnet; grossularite, in the pink variety just mentioned; essonite, or cinnamon garnet, described by Damour as occurring in light-red

* Carlos Sellerier on the "Minerals of Mexico," Buffalo, 1901.

dodecahedral crystals in limestone; and almandite. Other members of the group undoubtedly occur, but have not been definitely determined, and no important localities are as yet known.

Topaz. — Topaz has been observed at many localities in Mexico, from Zacatecas all the way south to San Luis Potosi. In the Tepazon mountains, southwest of the latter place, and at the Hacienda Tepezate, at Pinos, seventy-five miles northwest of it, fine crystals have been obtained. They vary from colorless to rich wine-yellow, and from one to three inches in length, and are sometimes double-terminated, with brilliant faces. At these places they occur either in an eruptive rock of the rhyolite series, like that at Thomas mountain, in Utah, or in a kaolin, which is doubtless the same or a similar rock, in a soft decomposed condition. Specimens of great beauty in the Berlin museum, presented by Dr. Soriano, of Mexico, are labeled as from one or two other points near San Luis Potosi—"Mesa de San José Buenavista" and "Mesa de Santa Cruz."

In Durango and Guanajuato, topaz occurs in its characteristic association with tin-ores. At Coneto, in the former State, it is abundant in connection with durangite and cassiterite, in the tin-bearing sands, resulting from the breaking-down of the trachyte rocks. The crystals are small, rarely over half an inch long, but brilliant, and of various tints, from colorless to yellow or pink red, and at times smoky black from included cassiterite. They are colored by tin in every case. At La Paz, in Guanajuato, large crystals, colorless or clouded, are found with tin-ore. At some other Mexican localities, colorless topaz crystals have been observed containing inclusions of rutile. These colorless topazes are believed to be in all cases the result of a natural bleaching-process, in which the original tint, probably yellow, has been lost by exposure and weathering.

The Mexican topazes are familiar as mineralogical specimens, but it does not appear that any systematic attempt has been made to develop the localities with a view to their use as gems. So far as known, none of them would afford gems exceeding a few carats in weight.

Turquoise.—This stone, although much used and highly valued by the Aztecs, is not known to occur in the present territory of the Mexican Republic. Many objects of ancient work

—carved, inlaid, or encrusted with turquoise—are found in Mexico, and it was doubtless one of several kinds of green stones included under the name of Chalchihuitl. But all the true turquoise so used evidently came from the mines in New Mexico, Arizona and California, where there are abundant evidences of extensive ancient working. Yet it may have been obtained from some locality since forgotten, as the jadeite locality has been.*

The Quartz Gems.—Clear crystalline quartz, or rock-crystal, was used by the Aztecs in the manufacture of some remarkable carved objects—particularly crystal skulls, which have attracted much attention among archæologists; but where the material was obtained is not known. It is reported as occurring near Pachuca and Hidalgo, in the State of Michoacan, and in veins near La Paz, in Lower California. The center of the vein is said to be beautifully pellucid, while the sides are opaque white. It is possible, however, that the larger pieces used for the carvings may have been brought from the remarkable locality of transparent rock-crystal in Calaveras county, California. The largest skull shows inclusions of prochlorite in the quartz of which it is made, a feature which also characterizes the Calaveras quartz.

Examples of these rock-crystal skulls are to be seen in the Blake collection in the U. S. National Museum at Washington; the collection of the late A. E. Douglas, in the American Museum of Natural History, New York city; and the Trocadéro Museum in Paris. The largest one, however, is now in the Archæological Department of the British Museum, for which it was secured by Sir John Evans, during his visit to the United States in 1897, by purchase from Messrs. Tiffany & Co. It weighs 175¼ Troy ounces and measures 210 millimeters ($8\frac{3}{16}$ in.) in length, 136 millimeters ($5\frac{3}{8}$ in.) in width, and 148 millimeters ($5\frac{11}{16}$ in.) in height. The eyes are deep hollows; the line separating the upper from the lower row of teeth has evidently been produced by a wheel made to revolve by a string held in the hand, or possibly by a string stretched across a bow, and is very characteristic of Mexican work. Little is known

* The masks, daggers and encrusted human skulls are more fully described on later pages of this paper, and in the writer's work on *Gems and Precious Stones of N. A.*, already cited.

of its history and nothing of its origin. It was brought from Mexico by a Spanish officer, some time before the French occupation of Mexico, and was sold to an English collector, at whose death it passed into the hands of E. Boban, of Paris, and then became the property of Tiffany & Co. That such large articles of wrought rock-crystal are not to be found in Mexico might lead one to infer its possible Chinese or Japanese origin. But it is evident that the workmanship of the skull is not Chinese or Japanese, since, in that case, nature would have been more closely copied; while, if the work were of European origin, it would undoubtedly have been more carefully finished in some minor details.

Prof. Edward S. Morse, of Salem, Mass., who resided in Japan for several years, and Tatui Baba, of Japan, once of New York city, declare positively that this skull is not of Japanese origin. Mr. Baba gives as one reason for his belief, that the Japanese would never cut such an object as a skull from so precious a material.

In ancient Mexico there was undoubtedly a veneration for skulls, for we find not only small skulls of rock-crystal, but real skulls, notably the one in the Christy collection in the British Museum, encrusted with turquoise. It may have been one of these that suggested the making of this skull, the one at the Trocadéro Museum, and the smaller one.

Two very interesting quartz crescents are known: one in the Trocadéro Museum; the other in the collection of Prof. Maxwell Sommerville, in the Museum of the University of Pennsylvania. Beads of this material are sometimes found in the tombs with jadeite and other stone beads. They rarely have a diameter of an inch.

Labrets (lip-ornaments) are occasionally found. But the wonderful crystal tablet now in the Field Columbian Museum, Chicago, is one of the most interesting and beautiful objects, made of Mexican rock crystal, now in existence.

Among other varieties of quartz minerals, reference may be made to a prase or green quartz, which appears as a wrought material in some of the ancient articles of Aztec carving—notably a great votive adze in the British Museum collection, which has passed under the name of *chalchuit* or *chalchihuitl* or jade. The source of this material is not known; it may be beyond the Mexican boundary or in Central America.

The amethysts from the silver-mines of Guanajuato have a world-wide reputation. They are found in large quantities, associated with pink and white apophyllite, and ranging in color from the most delicate lilac to the deepest purple. The crystals are frequently light in color at the base, but very much darker at the terminations. Groups a foot across are often obtained, but not good enough to cut as gems. It is certain, also, that fine amethysts were formerly found at some other locality in Mexico; for collections, both in the United States and abroad, contain fine objects made by the Aztecs, but not at all resembling the Guanajuato mineral They are deep purple, and more than 2 in. long, each being cut from a single crystal.

Chalcedony, agate, jasper, and the other varieties of quartz undoubtedly exist in abundance at many places in Mexico and Central America, judging from the numbers of objects, such as beads, figures and ornaments, shown in the collections. Some finely carved agate figures, 6 in. in length, are in the Blake collection in the United States Museum; and similar objects exist in the collections of other museums.

The name of "Cyclops" has been given to a peculiar occurrence of red and white chalcedony in concentric layers of concretionary growth, evidently from a solution, found in Chihuahua, about 1895, by Mr. E. J. Smith, of Chicago, who proposed the name. The specimens are, for the most part, small nodules, nearly hemispherical, and averaging half an inch in diameter. The center consists of a little nodule of red chalcedony, which is overlain and surrounded by clear colorless chalcedony. When the convex surface is polished *en cabochon*, the red center shows very strikingly, producing an eye-like effect; and the stones make attractive rings, scarf-pins and the like.

But it is the other species of silica, opal, that is by far the most important among Mexican gems, and the only one actually mined to any extent in the Republic. All the varieties of it are found both in Mexico and Central America; but the "noble opal" is more abundant in the latter than in the former country. The opal consists principally of silica, differing from quartz, however, in being never crystalline, and in containing from 3 to 12 parts of water in 100. The specific gravity of quartz is 2.65; of opal, about 2.2. Quartz has a hardness of 7, and opal of only 6, and even as low as 5.5.

Noble opal is the harder variety, in which the color is uniformly distributed, and ranges from opaque white to almost the pellucidity of glass. Fire-opal or girasol is the variety showing flashes of red and yellow, green and other colors, the opal itself ranging from colorless to white, transparent yellow, reddish brown to almost opaque. It is usually less hard than the noble opal. The names *lechosos* and *zeasite* are given by the Mexicans to the variety showing deep-green flashes of color. The name harlequin is applied to the variety in which the patches of color are small, angular, variously tinted, but evenly distributed. Common opal, so called, exhibits no play of color. This variety is found of many hues, chiefly, however, milky, pale green and rose-colored (when it is called quincite).

Hyalite, or Mullers' glass, is a colorless, transparent, jelly-like variety, usually occurring in botryoidal masses. Semi-opal is an impure variety of opal. When opal is mingled with agate or jasper it is called opal-agate or opal-jasper; opalized wood is the name used when opal-silica, as a fossilizing agent, replaces wood; hydrophane is a variety that becomes transparent, and sometimes shows a play of colors on being wet; and moss-opal is opal containing dendritic or moss-like markings, due to minute crystalline enclosures of oxide of manganese or of iron.

Opal is mined in a number of States of the Mexican Republic, notably in Queretaro, Hidalgo, Guerrero, Michoacan, Jalisco and San Louis Potosi. The most extensive and important are those in Queretaro, at and near La Esperanza; but those at Zimapan, in Hidalgo, have been known for a much longer time. In Guerrero, the chief localities are at Huitzuco and San Nicolas del Oro, where the material is described as transparent, streaked with red, green and blue. Magnificent gems have been obtained from this State; and one opal mine-owner in Mexico is said to export thence from $10,000 to $12,000 worth yearly.

The Hidalgo opals have been referred to as the first that attracted extensive notice. Del Rio mentions that in 1802, in Zimapan, near the sanctuary of Guadalupe Hidalgo, hyacinth-red fire-opals were found in abundance in a red trachytic porphyry; the same variety is mentioned by Sonnenschmidt as occurring in the mine of Toliman, in a trachytic conglomerate. John Mawe, in his work on precious stones, published in 1812,

mentions these opals as having been sent to England in quantities at that time. The fire-opal still occurs in its greatest perfection in the porphyritic rocks at Zimapan. It is generally of translucent hyacinth-red or topaz color, and sends forth gleams of fiery carmine-red, with more or less intense yellow and green reflections. When these opals are still in the compact red porphyry, they form objects of remarkable beauty, the flashes of red, green, yellow and blue color intermingling as the light falls on them. A beautiful opal from this locality, exhibited by the Mexican Commission at the Centennial Exposition at Philadelphia in 1876, was very greatly admired by visitors. Later, it went into the Leidy collection; then into the Lynde collection; and it is now in the Tiffany collection, Field Columbian Museum, Chicago.

An opal from Zimapan was analyzed by Klaproth, with the following results:

Silica, ...	92.00
Peroxide of iron, ...	0.25
Water, ...	7.75
Total, ...	100.00

The most extensive opal-mining, however, is in the State of Queretaro, where large quantities are produced and cut annually. The process of cutting is primitive and slow; but many opals are cut in a day upon common grindstones and polished upon wooden wheels, the stones being very soft. They vary greatly in quality, and values range from 1 cent to $100 (Mexican) per specimen; $200, $500, and even $1000 has been paid for the finest found. The ordinary grades are very cheap, owing to the fact that they are either penetrated with cracks, or are liable to lose their color; nor are the stones of fine quality free from the risk of cracking, or of losing their play of color, especially after the lapse of time. But this subject will be considered more fully below.

In 1890, the writer visited the opal-mines of Esperanza, ten leagues northwest of San Juan del Rio, in Queretaro. They are very extensive, having been traced over a district thirty leagues long and twenty leagues wide. They were discovered in 1855, by a farm-laborer, on the landed estates on which they are situated; but it was 1870 before a settlement was made on the edge of the mountain Ceja de Leon, by José Maria Siurob,

near the present mine of "Santa Maria Iris." In 1873, Dr. Mariano de la Barcena made a special report on this opal-district, in which he states that he has discovered ten veins, or "mines." He says:

"The opals of Esperanza are found forming chains more or less regular, on the banks of porphyry in quartz, which forms its base, or disseminated through the mass of the same rock. Veins (*i.e.*, dikes) of porphyry are met with in regular banks, which in many cases preserve the same direction as on the hill of Ceja de Leon, southeast to northwest. The porphyry is a grayish-red color, . . . changing to reddish-white on the surface where it is altered. The aspect of the porphyry indicates generally the kind of opal it contains. Where the rock is brick-red in color, hard and compact, the varieties with a fiery-red color abound, also the tints combined with red, formed from different changeable colors, or rather a mixture of colors. Where the porphyry is paler and mottled, noble opals are found more abundantly, notably in the mines situated on the hill of Peineta."

These mines are remarkable for the richness and variety of their product. In a single piece of rock from the Simpatica mine, Dr. Barcena found four kinds—noble opal, fire-opal, harlequin and *lechosos*. Clear opals, with little fire, are abundant and cheap. The Jurado, the author found, had been excavated for some hundreds of feet in length and 100 ft. in width to 150 ft. in depth, at which level the porphyritic rock abounds in common opal and opalsilica. The noble opals at Esperanza are remarkable for the extent and intensity of their reflections. The harlequin opals are noted for the diversity and the small size of their colored spots, which resemble beautiful miniature mosaics. One of the most pleasing varieties has a play of red fire, like those from Zimapan, mingled with flashes of brilliant metallic emerald green, and occasionally a violet-blue of remarkable intensity. One of the red varieties from the Rosario mine, on the hill of Jurado, has a violet-blue reflection of peculiar beauty, and the same mine has produced a variety with a metallic emerald-green and a dark ultramarine color combined, or rather showing one after the other. The *lechosos* opals, as those with the red and green reflections are called in Mexico, are very common on the hill of Peineta, and less plentiful in the other mines of Queretaro. Other localities reported in the same State occur on the Batan, Gallindo and Lallare properties, in the district of Amealo. Those in the State of Guerrero have already been referred to. In San Luis Potosi, both common

and fire-opal have been observed on the ridge of Mount Mezquitic, and at one or two other points.

Most of the cutting is done in the city of Queretaro, some 75 miles from the Esperanza mines. The miners receive an average of twenty-three cents per day for their labor. Thousands of opals are sold every year to visitors and tourists in the cities of Mexico and Queretaro, and at railroad stations in Mexico, New Mexico, Arizona and Texas, while many thousands of the poorer grade of handsome stones are exported to Germany, to be mounted in cheap jewelry. The poor stones often sell at from $1 to $10 a hundred.* Fine stones, rarely or never sold or even shown to tourists, sell for $10, $50, $100, or $500; and even $1000 has been paid for a single stone. Notwithstanding the great beauty of the Mexican stones, they suffer under two disadvantages. Much of the noble variety occurs only in thin layers, between or upon bands of common opal with little or no fire. Often half or two-thirds of a cavity containing this variety is filled with these layers or bands, like those in an agate, sometimes no thicker than a sheet of paper. Frequently the upper layer consists of hyalite, a colorless, jelly-like form, showing no play of color; or there is a brilliant but very thin layer of opal, not thick enough to be polished. These cavities often contain, also, circular crystals of rutile, which penetrate the opal; and this is possibly the coloring-matter of the yellow and red varieties.

The other disadvantage is the one already briefly mentioned, namely, a liability, real or supposed, to lose color, in a longer or shorter time, under conditions that are not well understood. In this respect the Mexican noble opals are inferior to those of Hungary and of Australia, which do not appear to have this defect. Although the reports are perhaps exaggerated, there is no doubt that such a loss does occur at times. It is specially noted in the colorless fire-opal variety (which seems to be as sensitive as it is gorgeous), and in the flame-opal; and it is frequent in the poorer and cracked varieties, which, for this reason,

* It is a frequent practice of dealers to keep poor opals immersed in oil and water for long periods, and to take them out only when a buyer presents himself. The temporary brilliancy and play of color, thus imparted, disappears with the evaporation of the absorbed moisture. Very poor opals are often soaked in oil, and then oil is burned on them. This causes them to crack and to absorb the burnt oil—the result being "black" opals, which possess enhanced brilliancy, but little strength or durability.

are sold very cheap. The report prepared by the Mexican Commission at the Paris Exposition of 1900, says that in 1891, at some localities not specified, in the States of Michoacan, Guerrero and Queretaro, opals of unusual hardness and notably free from this tendency were discovered. Such a discovery, if confirmed by further development, will have much interest, from both the scientific and the practical standpoint.

The whole subject of this loss of color, etc., long so perplexing, and of so much importance in connection with these beautiful gems, has resolved itself into the fact that opals containing from 5 to 10 per cent. of water (supersaturated silica, as it were) have gradually dried out and cracked. These were nearly always colorless, with large flames. In other varieties, containing 5 per cent. or less of water, this defect has rarely been manifested. The change sometimes occurs without apparent cause, and has been attributed to variations of the weather in temperature and moisture. But stones have been known to lose their brilliancy even when apparently removed from the influence of atmospheric changes, as when wrapped in paper and placed in a jeweler's safe or in a collector's cabinet.

Some years ago our late President and fellow-member, Prof. Egleston, the founder of the Columbia School of Mines, and recognized as an expert collector and judge of minerals and gems, possessed a small glass bottle, filled with cut opals of extreme beauty. He said that they had been given to him by a prominent jewelry firm in New York as entirely worthless, having completely lost their color; that he took them as specimens simply, and placed them in his cabinet, where, after awhile, they had recovered all their former brilliancy and fire. The only explanation that he could suggest was that the basement-room in which his cabinet stood might have been somewhat more damp than the store from which the opal had been brought. It is certain, however, that the room was not so damp as to render it unpleasant or unsafe; and the change as to moisture must have been but slight. It would be interesting to know what was the subsequent behavior of the same stones; but on this point we have no information. Keeping opals in oil prevents their cracking by preventing their drying.

Probably the widespread superstition which once prevailed, but has now almost, if not entirely, disappeared, as to the opal

being an "unlucky" stone, may have originated from circumstances of this kind.

On the other hand, many opals are as enduring as could be desired. Perhaps the most celebrated Mexican opal is the one sold some years ago in the collection of the late Philip Henry Hope, now in the Tiffany collection, Higinbotham Hall, Field Columbian Museum, Chicago. It is a fire-opal, or "sun-opal," carved with the head of the Mexican sun-god, and is believed to have been taken from a temple. It has been known since the sixteenth century, and brought £262 sterling at the sale of the Hope jewels in London in 1886.* A remarkable fire-opal, brought from Mexico by Alexander von Humboldt, is preserved in the Mineralogical Museum at Berlin. In these notable instances, as in countless others, there seems to have been no deterioration.

The Spanish historians, in their marvelous tales of the wonders seen in Mexico at the time of the Conquest, describe the image of the mystic deity, Quetzalcoatl—god of the air—on the great pyramid of Cholula, as wearing a "mitre" or head-dress waving with plumes of fire. This effect is supposed to have been produced by masses of mosaics of fire-opal. The conception is splendid, and as characteristic of Aztec art as the marvelous golden image of the sun, encrusted with "emeralds" (evidently green jadeite), facing and reflecting the morning rays on the wall of the temple of the sun at Cuzco, was characteristic of the Inca art of Peru.

Beautiful exhibits of Mexican opals have been made at the recent World's Fairs, from the time of the Centennial down to the present. At the Paris Exposition of 1889, the fire-opals and noble opals shown by the Mexican Commission—particularly one large specimen with superb pink flame—attracted much attention. One very remarkable specimen from the Iris mine, Queretaro, has been described by the writer. It was a nodular mass, as large as a hen's egg, of fire-opal, in trachyte, and was penetrated by yellow, polished and iridescent acicular crystals. It is not certain what these were, but they were evidently rutile. The specimen is in the Harvard University collection.

Some of the mixed varieties of Mexican opal, although not suitable for cutting into gems, have fine possibilities as ornamental materials of great elegance. Such is a beautiful variety

* Catalogue, Hope Collection, pl. xxxi., Fig. 3, p. 3. London, 1839.

of opal-agate, found in the State of Jalisco, in which pink, yellow and green, especially of the softer shades, occur together, blended and veined in the most pleasing manner. It exists in considerable quantity, and is valued as a decorative stone for metal-work or jewelry.

Chalchihuitl, a name celebrated in Mexican archæology, was applied to certain green stones capable of high polish, which were carved into various ornamental forms, and very highly valued. There has been much mystery and much discussion as to what this precious material really was, and whence it was obtained. It seems evident that several minerals were included under this name—among them a green quartz or prase, some of the deeper green varieties of *tecalo* or Mexican onyx (so-called), and probably turquoise; but the precious *chalchihuitl* has now been proved to be jadeite, a stone which has possessed a singular charm for many aboriginal peoples in widely separated parts of the globe, but which, for some reason, has not so much attracted the notice or the taste of the "historic races."

When attention began to be drawn, some thirty years ago, to the turquoise mines near Santa Fé, New Mexico, the eminent geologist and explorer, Prof. William P. Blake, noting the evidences of ancient workings at those mines, and the traditions still preserved among the native tribes of the region as to the sacredness of the stone and its association with Montezuma, felt assured that here was the solution of the *chalchihuitl* mystery. The stone must be no other than turquoise; and here were the evidences of its long-lost source. At first sight this view was highly satisfactory, and it was widely accepted; but later investigation has not confirmed it, except in part. Two objections are conclusive: (1) that turquoise never occurs in masses of sufficient size to make objects like many of the *chalchihuitls*; (2) that the ancient Mexican tribute-rolls distinctly show that *chalchihuitl* was a product of southern Mexico—the region between the capital and Central America. To set at rest all questioning, moreover, chemical analysis proves that the real *chalchihuitl* is not turquoise, but jade.

Under the name jade, however, are included two minerals, nephrite and jadeite, closely similar in appearance and properties, which were separated by Damour in 1865. Jadeite is a silicate of alumina and soda, classed in the pyroxene group by

mineralogists, while nephrite is a variety of amphibole or hornblende, a silicate of alumina, lime and magnesia.

In Mexico and Central America jadeite only is found, not nephrite, while among the jades of the northwest coast of America and Siberia, in New Zealand and Oceanica, jadeite has not yet been recognized. The Mexican jadeite has been treated of by Damour;* and a number of specimens in the United States National Museum have been described by Clarke and Merrill in their article "On Nephrite and Jadeite.† These specimens vary widely in color, from light to dark and from dull to bright greens (some plain and some mottled), and from translucent to opaque, but agree closely in their specific gravities, which were carefully taken by Dr. William Hallock, and are all above 3. Those that were analyzed gave very nearly the regular composition of jadeite, a silicate of alumina and soda.

The Central America series of jades in the same collection are mostly from Costa Rica, with some from Guatemala and Nicaragua. They also are principally true jadeite, with density above 3; though some appear to be green quartz (resembling prase), and others, of much less hardness and density, are indeterminate minerals of various kinds. No nephrite is recognized among them. The same variations in color, etc., appear in these as in the Mexican jadeites.

In thin sections under the microscope the jadeites present a distinctly crystalline, or granular-crystalline, texture, in which sometimes the cleavages, and even the crystal-angles, can be recognized: from these the pyroxene character of the mineral is definitely traceable. The nephrite jades, on the other hand, show a minutely fibrous, scaly and lamellar structure when magnified. There are, however, intervening types; and the structure alone may not in every instance be relied upon to distinguish the two species.

Nephrite is in some cases a secondary mineral, arising from the alteration of pyroxenes into hornblendes (the change called uralitization); and hence, as Clarke and Merrill suggest,‡ it may be well said that "a true nephrite may graduate into a granular diopside rock resembling jadeite," according as the

* *Bull. Société Mineralogique*, iv., 157.

† *Proc. U. S. Nat. Museum*, xi., 1888, pp. 121–125.

‡ *Loc. cit.*, p. 129.

change has advanced more or less. But the density of nephrite is always below 3, and that of jadeite always above 3.

The name jade is from the Spanish *piedra de hijada*, or "stone of the loins"; it is first mentioned under this name in the writings of Monardas in 1565, and had been brought from Mexico and Peru with this designation, arising from its supposed efficacy in diseases of the loins and kidneys. This idea entered into all the nomenclature of these allied stones; the Spanish term was used in its Latin form, *lapis nephriticus*, by Clutius in 1627; Linnaeus called it *talcum nephriticum* in 1768; and Werner gave it the mineralogical form *nephrit* in 1780. The Germans named it *Nierenstein* and *Beilstein;* the French, *pierre néphrétique*, with other familiar variations.

It is evident that the *chalchihuitl* stone was highly prized among the natives in various ways. Besides its reputation for curative or preventive power against certain forms of disease, it was valued for its beauty of color in the finer varieties, and was carved into objects of ornament. It seems also to have possessed some kind of mystic sacredness, religious or ancestral, like that attached to turquoise by the traditions of Montezuma and the ancient turquoise mines, which still linger among the native tribes of New Mexico and Arizona. How far these ideas were blended, or what connection existed between them, it is impossible to determine. The curative powers may have been ascribed to some deity to whom the stone was sacred, and the wearing of beads or of carved amulets may have been partly religious and partly sanitary in motive, while finer specimens and rarer varieties may have been reserved as the special prerogative of royal or sacerdotal chieftains, and worn as insignia of exalted rank.

When we consider how superstitious were the Europeans of the 16th and 17th centuries, it seems also possible the voyagers, adventurers and sailors who brought home the jadeite as loot, originated its supposed virtues in their fertile brains, to enhance its value for gift or for sale, even though the natives never attached such properties to the mineral.

Many specimens of carved jades were brought over early to Spain; but it is probable that the most remarkable were lost. Wonderful tales were told of the carved articles of "emerald" belonging to Montezuma, including a goblet and a "rose," which were shipped by Cortez to the King of Spain, among

the choicest treasures of the conquest. Unfortunately the vessel that bore them foundered at sea, and these unique works were forever lost. It is impossible that they can really have been of emerald, as that gem scarcely occurs in Mexico at all. They were probably *chalchihuitls* of peculiar richness of color, and constituting, doubtless, both in material and in workmanship, the finest products of Aztec art.

The most remarkable specimens now known of jadeite from Mexico are chiefly carved masks or pendants or celts or adzes, these latter also being often carved and elaborately ornamented, showing that they were insignia of rank, and not implements for use. Many of them retain on the back or sides portions of original rounded surfaces, proving that they were made from boulders. In several instances, large pieces have been reduced by cutting out smaller portions from the back, leaving the carved face uninjured—thus indicating either increasing scarcity of high-priced material, which induced the removal of superfluous portions to make new objects, or perhaps some peculiar tradition or superstition, attributing special sacredness to pieces once belonging to some deceased chieftain, which might be perpetuated to his successors by bestowing on them parts thereof, while the main original was buried with its possessor.

The "Kunz" jadeite adze in the American Museum of Natural History, New York City, which has been described by the writer, is believed to be the largest known. On its face is carved a grotesque human figure; and, for so hard a material, the workmanship is excellent. It is said to have been found about 1869, in Oaxaca. It measures 272 mm. (10.13 in.) in length, 153 mm. (6 in.) in width, and 118 mm. (4.63 in.) in thickness, and weighs 229.3 Troy ounces. Across the ears it is 153 mm. (6 in.); across the lower axe-end, 82 mm. (3.25 in.); the height of the head down to the neck is 158 mm. (6.25 in.); the height from chin to foot, 115 mm. (4.5 in.), and the length of the legs 50 mm. (2 in.). From the back a piece about 160 mm. (6.5 in.) long and 50 mm. (2 in.) wide has been removed.

The color is light grayish green with a tinge of blue, and streaks of almost emerald-green on the back. In style of ornamentation it very closely resembles a gigantic adze of granite, 57 centim. long and 34 wide, mentioned by A. Chavero; and it has almost a counterpart in a green aventurine quartz adze,

now forming part of the Christy collection at the British Museum, and formerly in the possession of Percy Doyle, Esq., of the British diplomatic service. It differs from these two objects, however, in having no ornamentation on the forehead, and in having four dull markings on each ear, one under each eye, and one near each hand, which seemingly could have served no other purpose than to hold thin plates or films of gold, which the polished surfaces would not do. If this was so, no trace of the gold can now be seen. From all appearances, this adze was shaped from a boulder, since weathered surfaces, such as appear on all sides of it, would be found only on an exposed fragment. The dull markings show a tiger's or serpent's head on the brightly polished human face. The lapidarian work on this piece is probably equal to anything that has been found, and the polish is as fine as that of modern times.

A feature of great interest is the removal from the back of two portions, which must have weighed fully 2 lbs. Why was this done? Similar removals and divisions have been mentioned in other cases. In a paper read April 27, 1881, before the American Antiquarian Society, Philip J. J. Valentini described two carved jadeites which showed similar treatment. One was the Humboldt celt, a votive adze presented to Humboldt by Del Rio in 1803, and the other the so-called Leyden plate, which was found by S. A. von Braam near San Félipe, in Honduras, near the borders of Guatemala, and given by him to the Leyden museum. These objects are 9 in. long and 3.25 broad; the former being 1.4 in. and the latter 0.6 in. thick. (The fact that the two, if placed together, face to face, correspond exactly in outline, makes it highly probable that they were originally part of one and the same celt; and it is quite possible that the remaining parts may yet be found.) In 1886 Professor Frederick W. Putnam exhibited before the same society a remarkable series of Nicaraguan and Costa Rican jadeites, which were all ornaments, and showed that they had been made by cutting celts, which had been perforated by one or two drilled holes, into halves, thirds and quarters. In one instance two of them fitted together. The explanation suggested was that, the supply of the material having become exhausted, recourse was had to division, or the removal of a part from existing articles for the purpose of making others, perhaps to be

buried with some dead chief, or to be bestowed as sacred treasures on new branches of the tribe.

Fully one-eighth has been thus removed from the back of this adze; and the manner in which the instrument used in its removal was held has produced a rounded cut on each side, lending probability to the supposition that some abrasive was employed, drawn with a string held in the hands, or stretched across a bow. If the Aztecs knew of the existence of corundum, we can better understand how they worked so large a mass of tough and hard material. But corundum is hardly known in Mexico; and it may be remembered that the New Zealand Maoris cut and carved their jade articles by means of thin slabs of hard, gritty, fine-grained sandstone.

So far as the writer has been able to learn, no similar object of equal magnitude and archæological interest exists. The next most important specimen is a large jadeite celt, described by Dr. A. B. Meyer as belonging to the Royal Ethnological museum at Dresden. This, however, weighs only 7 lbs., and is wholly devoid of ornamentation. Nor will the Humboldt celt or the Leyden plate, above referred to, compare with it at all.

Various other jadeite articles of similar character have been exhibited and described, but many of them, like some of those already referred to, belong rather to Central America than to Mexico, or else are of uncertain locality. Among the latter is a curious little mask, apparently representing the face of a crying child, exhibited in 1879 before the American Association for the Advancement of Science by the late Mrs. Erminie A. Smith,* noted for her studies in American ethnology.

The late George P. Squier, the eminent archæologist, possessed a number of finely carved *calchihuitls*,† which he described and figured. Several of these were very brilliant in color, and might have been regarded by unskilled persons as carved, like the reputed treasures of Montezuma already mentioned, from opaque emerald. To a considerable extent, moreover, they bore Maya, rather than Aztec, symbols.

It seems that the veneration of *chalchihuitls* extended through

---

* *Proc. Am. Assoc. Adv. Science*, 1879, vol. xxviii., p. 523.

† Now in the Squire collection, at the American Museum of Natural History, New York city.

all Mexico, and Central America as well. The question, whence the material was obtained, is of great interest to archæologists; and its solution might bring into notice a beautiful ornamental stone for modern uses. As already remarked, jade has been prized and elaborately worked by many semi-civilized peoples, but never, until recent times, employed by the historic races. Yet its fine texture, its hardness, and the beautiful polish which it takes and retains, combined with its rich and delicate tints, and its translucency, render it a material of great possibilities. Only within a few years has the first attempt been made to utilize jade as a "civilized" ornamental stone. This was done at the Paris Expositions of 1878, 1889 and 1900, in the remarkable exhibit of Siberian nephrite made by the noted Russian explorer, M. Alibert.* The display was one of extreme beauty and interest, and showed that this stone was abundantly capable, at the hands of European artists, of yielding the finest results, equalling or surpassing the long-celebrated Chinese work. If the locality of the rich green *chalchihuitls* of Mexico and Central America could be found, and the material could be obtained in any useful quantity, it would be a beautiful addition to our ornamental stones, as well as an interesting discovery from the standpoint of science.

It is to be hoped that before many years this problem may be solved. Much of the carved Mexican material was evidently obtained from boulders and rolled pieces, carried down by streams from unknown localities in the mountains. But, in some instances, it seems that the ancient Mexicans must have known the mineral in place.

The whole situation is curiously parallel to that of the "oceanic jade" of New Zealand, where that substance, so much prized and venerated, was derived almost entirely from boulders in certain streams, and the actual places of occurrence were unknown, save perhaps as a secret to a very few.

A valuable and important paper has been published during the past year by the well-known archæologist, Mrs. Zelia Nuttall, embodying the results of an extended investigation as to the probable sources of the jadeite, which appears so prominently in early Mexican documents. The chronicle of Tezo-

* The writer saw at the Imperial Lapidary Works, at Peterhoff, Russia, a canopy of jade (nephrite) 15 ft. high, that was being made for Alexander III.

zomoc relates the conquest of the southern tribes of Mexico by Ahuitzotl in 1497, and the terms granted by him to them, which comprised various forms of tribute—gold, skins, plumage and precious stones—first among which was named *chalchihuitl*, of all varieties. Twenty-two years later, at the time of the Spanish invasion, the tribute-roll of Montezuma gave full lists of towns from which *chalchihuitl* was sent to the capital. A copy of this celebrated tribute-roll, sent by Cortez to Charles V, shows that a large number of places in the region of Ahuitzotl's victories, in Southwestern Mexico, had continued this tribute down to Montezuma's time, as had been done also by a number of other localities, not so near to the region named.

Mrs. Nuttall undertook, by a close examination of these ancient lists of towns, to identify them, as far as possible, with existing localities. The lapse of four centuries, and the replacement of native by Spanish names, might seem to render this attempt well-nigh hopeless. But it is surprising how large a proportion of them are clearly recognizable—sometimes modified, but often almost unchanged. Others, not yet identified, may possibly be traced hereafter by more minute local investigation. Mrs. Nuttall has employed the best and latest maps, and has carefully excluded all identifications that were at all doubtful.

On grouping these localities and studying their relation, they arranged themselves in an interesting manner. They all belong to a region extending from the Isthmus of Tehuantepec, the scene of Ahuitzotl's victories, southeastward through the State of Chiapas to the Pacific Ocean and the border of Guatemala, and northwestward through the four States of Vera Cruz, Puebla, Oaxaca and Guerrero—the last three representing the native province of Mixtecapan.

Tables of the ancient and modern names are given by districts, accompanied by maps on which the identified points are marked. These very interesting maps show that the precious mineral was obtained at numerous places throughout a wide region. For the determination of actual sources, however, with a view to their rediscovery, the facts elicited are perplexing, from their very abundance. But there are some special indications that may well be followed up.

In Chiapas, 9 towns appear in Montezuma's roll. Six of

these are clearly identified, lying near the Pacific Coast in the angle between it and the Guatemala line. A town inland, considerably northward of this group, and not named in the tribute-roll, bears to this day the name of Chalchihuitlan—the "land of *chalchihuitl.*" This region was not subdued by Ahuitzotl's conquest of Telmantepec, and required a second expedition to reduce it; but it finally became tributary on the same terms as the others. Here is apparently one district where the mineral could be found by sufficient search.

In the State of Oaxaca, or on the adjacent border of Vera Cruz, fifteen points are identified out of twenty-two in Montezuma's list. Six are identified in points in Vera Cruz; with 6 others uncertain, but evidently not far distant. Several of these are near the Gulf coast and north of the latitude of Mexico City. Proceeding thence inland, the map of the State of Pueblo shows no less than 23 places identified. Two or three are in the northern and southern portions of the State respectively, but most of them are grouped along the central zone lying between Orizaba on the east and Popocatepetl on the west, though tending rather southward of the latter, and passing over into the State of Guerrero, where 6 towns are grouped in the northeastern portion. The center of this group of localities would lie on a meridian line passing through the City of Mexico, about half-way between that city and the Pacific. This would appear to be another well-defined region where *chalchihuitl* must have occurred in place.

The Guerrero localities are inland. None are noted in the coast-region. There are two quite near the coast in Oaxaca, west of the Bay of Tehauntepec; and the coast-group in Chiapas, already mentioned, lies southeast of that bay, suggesting a line of occurrences along the Pacific, interrupted by the depression of the bay.

Mrs. Nuttall gives, in conclusion, a further list of those names of places in Mexico which apparently involve or include the word *chalchihuitl.* While these are suggestive and interesting, they may not all be important; but the name *Sierra de Chalchihuites*, given to a small range of mountains in the State of Zacatecas, near Sombrerete, and that of a mining town called *Chalchihuites*, at the northern end of the same range, certainly offer striking intimations.

This investigation is highly creditable to Mrs. Nuttall, and will undoubtedly stimulate and direct the search for jadeite, which evidently must occur at numerous points in Mexico, anciently familiar, but long forgotten and lost. Full geological investigation of the nature and distribution of the abundant crystalline rocks is the great desideratum for an intelligent further pursuit of this interesting inquiry.

A point not alluded to by Mrs. Nuttall, yet nevertheless of much significance, is the kind of material called for as tribute from four different sections: *i.e.*, whether "beads," that is, pebbles and rolled pieces, or larger single pieces, are specified. This point was noted twelve years ago by that eminent archæologist, the late Dr. D. G. Brinton, in discussing the tribute-roll in the *Codex Mendoza*, published in Lord Kingsborough's "Antiquities of Mexico" (London, 1830). Examination showed that all the lists given in Mrs. Nuttall's paper called for strings of *chalchihuitl beads* (one to five every six months), except in one section, where "three large pieces" were also required. The map shows that half or more of the identified localities in this section were grouped along the border of Oaxaca and Vera Cruz, about equally distributed on either side. Here is a well-defined region, southeast of the City of Mexico, and not far from Vera Cruz, in which the mineral must certainly exist in place. Other localities, from which only "beads" were called for, were plainly along water-courses, where rolled pieces alone were found. In these cases the material may yet be traced up-stream to the sources whence it was brought down by natural agencies; but these places were evidently unknown to the natives, then as now.

The region along the Oaxaca-Vera Cruz border, on the other hand, yielded larger pieces, doubtless from an actual occurrence in place.

It is interesting to observe how closely the studies of Mrs. Nuttall, read with this clue, support the suggestions of Dr. Brinton as to the most promising region for search. The *Codex Mendoza* calls for pieces, three every year, in addition to beads, usually from Tehualtepec, Chinantlan, and some other towns in Oaxaca, principally in the department of Valalta, a region described as wild and mountainous, inhabited by the Mixe In-

dians and the Chinantecas.* Dr. Brinton suggested that this district of Valalta was the most promising in which to seek for jadeite in large pieces, or perhaps actually in place.

It may be added here that there is in the writer's possession a rough piece of Mexican jadeite, fractured and sawed, not rolled, although it may have been broken from a boulder.

From the abundance of Central American specimens, it is apparent also that other *chalchihuitl* localities must exist, probably all the way south to Costa Rica.

Some eminent students of archæology have been inclined to believe that the jadeite objects found in the New World were not indigenous, but had been brought from Asia, where jade has been known, valued and wrought, from very ancient times. On this theory, supported by the supposed similarity between the Mayas and the ancient Burmese, the articles became evidences of the Asiatic origin of the American peoples, or at least of trans-Pacific communication and commerce. The chief exponent of this theory was the late Dr. Heinrich Fischer, of Freiburg, Baden, who devoted years to the study of the subject.† The grounds for it, however, were slight; the main one being the fact that jade had long been familiar in eastern Asia, and had not been previously known in America. Stress was laid on the removal of portions of large objects to make smaller ones, as though the precious material was very limited in amount, and becoming exhausted; but it is not certain that this was the real reason for this practice. As noted above, it may have been entirely different, and connected with some religious or ancestral tradition. Another argument was that the green jadeite of Burma, if heated,‡ assumes a brownish cast, such as appears in some American examples, presumably also from heating. But this is merely a presumption; and the fact that the green color of many silicates is due to protoxide of iron, which is altered to sesquioxide by heat, and then becomes brown, are enough to dispose of this scanty foundation for so important a theory.

In the same way the nephrite jade of Alaska was at first at-

* *Science*, vol. xii., p. 168, Oct., 1888.

† Muhlenpfordt, *Schilderung der Republik Mexico*, vol. ii., p. 213.

‡ In Burma, jadeite is mined by "fire-setting;" and in New Mexico turquoise was mined in the same way.

tributed to Siberian sources; but some years ago it was definitely determined to be of American origin.

On the other hand, Dr. A. B. Meyer, Director of the Ethnological Museum at Dresden, and other foreign students of the subject, opposed the views of Fischer, and argued from various premises for the indigenous character of the American jadeite.

More recently, the whole subject has been very thoroughly reviewed by Professors F. W. Clarke and George P. Merrill, of the United States National Museum.* The great collection of that museum contains a fine series of jadeite objects from Mexico, mostly from the State of Oaxaca, together with a number from Central America, the choicest of which are from Costa Rica. In summing up their conclusions, these writers find that the articles probably came from a number of localities, and are of no value whatever in tracing the migrations or the intercourse of races; that these minerals are not uncommon in metamorphic rocks, and hence are liable to occur wherever such rocks abound; so that their presence has no more significance as to tribal movements or aboriginal trade than pieces of graphite would have. The natives required and valued a hard, tough mineral, capable of receiving and retaining a sharp edge for adzes or celts, or a high polish for ornaments; and they utilized it wherever it was found.

As to the various stones included under the name of *chalchihuitl*, the following points may be noted in concluding this discussion:

The identity of jade with *chalchihuitl* was first suggested in 1866 by Prof. Raphael Pumpelly, in his article on the "Geology of China."† In 1883, as already noted, Prof. William P. Blake‡ had identified *chalchihuitl* with the New Mexican turquoise, and proposed the mineralogical name *chalchihuitl* for the bluish-green variety. Certain it is, however, that although turquoise was doubtless included under *chalchihuitl*, and, perhaps, was regarded as a specially choice variety, it formed but a part of the material so designated by the Aztecs. The tur-

* "On Nephrite and Jadeite," *Proc. U. S. Nat. Museum*, vol. xl. (1888), p. 115.

† *Smithsonian Contributions*, xv., 118.

‡ *Am. Jour. Sci.*, xxv., 227, 1858; xxv., 197, 1883.

quoise is never found in pieces of large size; it was used in the form of small beads, usually cylindrical, and for inlaying and encrusting various ornaments. In some cases skulls* are thus overlaid with a sort of mosaic pavement of turquoise. Such specimens may be seen in the British and Vatican museums in Europe, as well as masks and small animal figures. The early Spanish writers of the time of the Conquest refer frequently to turquoise, and identify it with *chalchihuitl* as a material greatly valued by the natives. Some of the presents made of this material, and sent by Montezuma, through Cortez, to the Emperor Charles V., are believed to be now among the crown-jewels of Spain. Coronado, in 1540 and 1541, and Friar Marco de Nica, who traveled through New Mexico in 1539, made frequent references to turquoise. It is said that the insurrection of the natives which led to the driving out of the Spaniards in 1556 was caused by their resistance to forced labor in the turquoise-mines.

The fact seems to be that the *chalchihuitl* so highly prized was jadeite in southern Mexico and Central America, and turquoise in northern Mexico and New Mexico. Each species is a green mineral, and was greatly valued, and made a matter of tribute to the crown; but the jadeite, as we have seen, is confined to the region south of the capital, while the turquoise is unknown there, but occurs at a number of localities in the territory acquired by the United States after the Mexican war. Not only the mines at Los Cerrillos, near Santa Fé, but every other locality discovered (and there are now a number), bear conspicuous traces of long and laborious working, in ancient times, by the crude methods of stone tools and fire, which the writer observed at Los Cerrillos.† It is thus abundantly proved that the turquoise was highly valued and largely used.

On the other hand, the evidence that the *chalchihuitl* of southern Mexico was jadeite has already been sufficiently dwelt upon. Nowhere, indeed, was this mineral regularly mined, like the turquoise of the northern region. Most of the material produced consisted of rolled boulders; and although, as we have seen, the exceptional requirement, for tribute, of

* *Am. Jour. Sci.*, xxv., 227 (1858); xxv., 197 (1883).

† See *Gems and Precious Stones of North America*, pp. 63–65.

pieces, in distinction from beads (*i.e.*, pebbles and boulders), points to a district on the border of Oaxaca and Vera Cruz, where it must probably have been found in place, the actual localities of such occurrence were generally unknown.

Other minerals, similarly used and designated, were: a green quartz, or prase; a variety of lamellar serpentine; some of the richer colored kinds of *tecali*, or Mexican onyx; and occasional undetermined materials of greenish color. It does not appear that the ancient Mexicans knew either malachite or chrysocolla, which would have made *chalchihuitls* of surpassing elegance. Had they discovered these beautiful minerals in copper-mines like the Globe and Copper Queen of Arizona, which have yielded such magnificent specimens, they would have prized them above anything that they possessed, and would have carved them into objects of regal treasure.

Friar Bernardo de Sahagun, in his *Historia de Neuva España* (lib. ii., chap. 8), says that *chalchihuitl* was a general term for choice green stones in one of the *nahuatl* (Mexican) languages. Any such mineral, somewhat translucent, and capable of taking a high polish, was highly esteemed. He gives the following varieties, distinguished by descriptive adjectives, in the native speech:

Iztac chalchihuitl (white *chalchihuitl*), of a fine green, quite transluscent, without stripes or stains.

Quetzal chalchihuitl (*precious chalchihuitl*): white, with much transparency, and a slight greenish tinge, somewhat like jasper.

Tlilavotic, literally "of a blackish watery color"; with mingled shades of green and black, partially transparent.

Tolteca-iztli, literally "Toltec knife" or "Toltec obsidian"; of a clear, translucent green, and very beautiful.

It is evident that the first is the so-called Mexican onyx, or Tecali marble, which exists in Tecali in veins, and is in reality an aragonite stalagmite. Great quantities of it were made into figures, ornaments, and beads, which are found all the way from northern Mexico down to Oaxaca. This so-called onyx is extensively quarried to this day, forming one of the richest ornamental stones (see *Mexican Onyx*, above).

Various green stones known at present were used in considerable abundance in ancient Mexico. Among eight green ob-

jects, sent to the writer at one time as jadeite, four were jadeite; one was laminated serpentine; another, a greenish quartz; and two a mixture of white feldspar and green hornblende. In a string of beads there were four pieces of true jadeite; but all the others were, like the jadeite beads, simply rounded pebbles, drilled from both sides; and there were nearly a dozen different substances in this string. The question is, were such pebbles a part of the tribute mentioned in the *Codex Mendoza?* Similar strings of pale green pebble-beads were exhibited under the name of jadeite in the Blake collection in the Mexican section of the Department of Ethnology, at the Buffalo Pan-American Exposition of 1901.

This confusion is not surprising. While no nation has used jade more extensively and for a greater period than the Chinese, yet it was only in 1865 that Damour isolated jadeite and nephrite as two forms of jade, and, still later, chloromelanite from jadeite, as a variety containing more iron and heavier in specific gravity. The Chinese experts and art-lovers are often mistaken; and a variety of green and white tough stones, such as light green and dark green prase, bowenite, fibrolite, quartzite, and others, have been, and are still, mistaken by them for jade. It was only when exact scientific investigation came into play that the true facts about many supposed valuable pieces were known. But, on the other hand, it is surprising how the Chinese, the Swiss lake-dwellers and the ancient Mexicans, recognized correctly the water-worn, iron-stained and apparently unrecognizable pebbles as jade or jadeite, whether they were selected for an art object, a celt or tool, or for an ornament.

Obsidian.—Strictly speaking, obsidian, or volcanic glass, could scarcely be considered as a precious stone; yet in Mexico it has been used in so many ways, has been so beautifully worked, that to omit it from this paper would be to ignore an ornamental material which figured more largely in ancient Mexican art than even jadeite.

This mineral, frequently found in connection with volcanoes and igneous outflows, is not a distinct species, but a peculiar glassy and non-crystalline form, assumed by several varieties of igneous rocks, rapidly cooled from the molten state. In such conditions, it seems that there has not been time for the

process of crystallization to take place, and the result is this glassy modification. The same thing is often seen in furnace-slags.

The name is a *nahuatl* (aboriginal Mexican) one; and the substance is abundant at various points in Mexico and the western United States—for instance, at the "obsidian cliff," a marked feature in the Yellowstone Park, and many localities in California, Nevada, and the Gila region in Arizona. It was a favorite stone among the Aztecs, and was mined extensively in Mexico for a great many purposes, both useful and ornamental. It could be "flaked" into knives and many other implements, with sharp cutting edges; and it could also be brilliantly polished. The knives used by the Aztec priests in their terrible rites of human sacrifice at the pyramids of the Sun and Moon at San Juan Teotihuacan, a short distance from the City of Mexico, were keen-edged obsidian flakes, of which great quantities are found near these pyramids. Similar implements, fragments, and the "cores" that were left when a mass had been flaked down as far as practicable, are abundant throughout Mexico, especially around ancient village-sites, and may be seen in almost any archæological collection.

Obsidian is generally velvety black, but varies to gray, and sometimes presents reflections of different tints—reddish-greenish, bluish, silvery or golden. It frequently contains multitudes of minute crystals, which yield these various reflections; and then the mineral may present a double color, black in one direction and golden *chatoyant* in another, usually at right angles to the black; giving, when properly cut, a "cat's-eye" effect, and forming the "obsidian cat's-eye."

It occurs at many Mexican localities, such as Tulanango, in the State of Hidalgo; near the village of Magdalena, in Jalisco; at Cadereita Mendez, in Queretaro; at Ucareo, Benjamo; and on the Pateo property, in Michoacan. But the chief locality, noted for its extensive ancient mines, is the Cerro de Navajas, or "Hill of Knives," on the Guajalate estate, near Pachuca, in the State of Hidalgo, northeast from Mexico City. This was the principal source of the material so largely employed for knives, arrow-points, spear-heads, masks, mirrors, and various objects of ornament.*

* Humboldt refers to it in his *Essai Politique sur la Nouvelle-Espagne*, vol. iii., p. 122.

For the first precise description of these mines we are indebted to Edward B. Tylor,* who visited that interesting spot in 1856, while traveling through Mexico in company with Mr. Christy. Besides many facts relating to the archæology and ethnology of Mexico, this writer furnishes the best observations on Mexican obsidian. Of the mines, he says:

"Some of the trachytic porphyry which forms the substance of the hills had happened to have cooled, under suitable conditions, from the molten state into a sort of slag, or volcanic glass, which is the obsidian in question; and in places this vitreous lava from one layer having flowed over another which was already cool, became regularly stratified. The mines were mere wells, not very deep, with horizontal workings into the obsidian, where it was very good, and in the thick layers. Round about were heaps of fragments, hundreds of tons of them; and it is clear, from the shape of these, that some of the manufacturing was done on the spot. There had been great numbers of pits worked, and it was from these little mines—*minillas*, as they are called—that we first got an idea how important an element this obsidian was in the old Aztec civilization. In excursions made since, we traveled over whole districts in the plains, where fragments of these arrows and knives were to be found literally at every step, mixed with fragments of pottery, and here and there a little clay idol."

This locality furnished a large part of the obsidian so widely distributed throughout the whole Southwest. In Mexico and Central America implements and fragments abound everywhere, indicating extensive traffic; and at points like Tenochtitlan (the modern City of Mexico) and San Juan Teotihuacan, the refuse-heaps are black with thousands of pieces.

An interesting account of these great obsidian mines in the State of Hidalgo has been given recently by Prof. W. H. Holmes, of the United States National Museum. They are among the most remarkable and important of the prehistoric mines found in various parts of North America.

"Prof. Holmes, Prof. G. K. Gilbert and Mr. W. W. Blake made the visit together. Leaving the railroad at Pachuca, the hacienda of the Guajalote estate is reached by a ride of 15 or 20 miles, and the mines themselves, several miles beyond, by a forest trail. They lie on the lower slopes of the Sierra de Las Navajas, or Mountain of the Knives. The slope is partly covered with long grass, partly with undergrowth, and partly with open pine woods; and as the actual mines are reached the surface becomes exceedingly irregular and difficult to traverse, owing to the alternation of heaps and ridges of obsidian fragments and the pits and excavations whence they came, half-concealed in the long grass and underbrush.

"Prof. Holmes compares these workings with those at the two great flint quar-

* *Anahuac, or Mexico and the Mexicans, Ancient and Modern.* London, 1861.

ries of North America—at Hot Springs, Ark., and Flint Ridge, Ohio—and estimates them as perhaps about equally extensive. They must have been exploited for a long period, as hundreds of acres have been worked over, and the ridges and depressions are practically continuous for 1 or 2 miles in length, and in some places for half a mile in breadth. There is no regularity whatever in their disposition; some are isolated pits, others coalesce and form half-continuous trenches over acres of ground. All are very fresh in appearance, although four centuries have passed since they were abandoned; but obsidian is a material that does not weather or decompose, and the flakes and fragments are as sharp and clean as if perfectly fresh. The trenches rarely exceed 6 or 8 feet in depth, and the heaps and ridges are but little more in height; but some of the excavations are like wells or pits, 15 or 20 feet deep, with vertical or overhanging sides. Prof. Holmes surmises, from the quantity of *débris* piled in horseshoe-like mounds around them, that these may have led to oblique or horizontal tunnels of some length; but it was not practicable to explore them for lack of tools.

"The material taken out from the ground must have been carried to certain points at hand; there tested as to its quality; and, if this proved good, trimmed into the cores that were taken away and widely distributed as an article of Aztec trade. The points where this testing and trimming were done are marked by immense piles of pure obsidian flakes and rejects, unmixed with any earth, and all perfectly sharp and fresh. The principal one of these heaps Prof. Holmes estimates to contain 20,000 to 30,000 cubic feet. It forms a long slope, with a flat top about 20 by 40 feet in area, where, doubtless, the workmen sat. Vestiges of rude stone buildings were recognized, one near this pile, and others lower on the slope of the hill; but all were reduced to low, ruined walls.

"The actual occurrence of the obsidian itself was not seen. There was no visible outcrop, and the pits and trenches were so filled up below with fragments and *débris* that the material could not be observed *in situ*. It must occur almost immediately beneath the surface, in irregular beds or masses of considerable extent. Many of the fragments are of large size and quite homogeneous. The color is chiefly black, or nearly so, though some is found of a paler shade—greenish, with chatoyant reflections. Hammer stones of tough lava, worn and battered by use, were the only tools or implements found. These were of two types, the larger ones discoidal or cheese-shaped, similar to North American forms, and the smaller ones nearly globular. They must have been used for breaking larger and smaller masses of the obsidian, respectively, but cannot have been employed for any of the finer shaping or flaking.

"Prof. Holmes gave much attention to the 'cores' or nuclei so familiar in all Mexican archæology as the source of the flaked knives and blades. The *débris*-heaps are full of these in an interesting form—cores roughly blocked out and then rejected as not valuable or satisfactory, owing to lack of homogeneity or of good flaking quality. Judging from those rejected, the average size must have been 4 or 5 inches in length and 2 to 4 in diameter. Larger ones are known, but are rare. They are rudely cylindrical or polygonal, and bear a few facets, made to test their quality. The number of better ones carried away must have been enormous.

"These nuclei were evidently distributed all over the country as the raw product of the mines, and were then worked up into all the forms of knives, razors, and other flaked implements, as well as those modified by chipping and shaping, as arrow-heads, scrapers, etc. The flaking was not done at the quarry,

as the delicate edges would be liable to injury in transportation. The further history of a 'core' is described and illustrated from abundant specimens by Prof. Holmes. The flaking was carried on upon any nucleus as implements were made from time to time, the size of the 'core' and the width of the flakes removed from it decreasing as the process went on. Whether the force was applied to the end of the nucleus by percussion or by pressure is not certain. Finally the core became so reduced that nothing more could be flaked from it, and these exhausted nuclei are common objects around old inhabited sites."

Obsidian objects are occasionally found in the United States as far east as Ohio and Tennessee. But it is useless to speculate as to their source, inasmuch as the distance from Central Ohio is about the same,—some 1700 miles,—to either the Yellowstone Park, the regions of the Gila, or ancient Mexican mines. Moreover, the number of such objects found east of the Mississippi is so small that little significance attaches to them.

The obsidian-work in ancient Mexico appears under three distinct types,—flaked objects, chipped objects, and polished objects. The knives, as already noted, were for the most part "flaked," by either pressure or percussion, from a mass, which finally became a "core." They are usually long, thin slips, with two parallel sides, exceedingly sharp-edged, and blunt ends, the sides being generally somewhat curved on their surfaces. These were fastened into handles, probably of wood, by asphalt or some black cementing substance, traces of which may often be seen at one end of the razor-like blade.

For arrows or spear-heads, the flaked piece was subjected to a chipping process, to produce a point and to give symmetry of form. Sometimes they were very large, and must have required a great amount of careful work. Two such blades or lance-heads 18 inches long, both Mexican, almost identical in form, and marvels of fine chipping, are preserved, one in the W. W. Blake collection, U. S. National Museum, Washington, D. C., and the other in the Trocadero collection, at Paris. One or two similar examples, though not quite as large, were shown in the Mexican section in the Ethnology Building at the Buffalo Pan-American Exposition of 1901.

The polished articles are objects of ornament,—mirrors, labrets and the like. Examples of these are to be seen in the National Museum at the City of Mexico; the U. S. National

Museum; the Trocadero collection at Paris; the British Museum; and in all leading archæological collections.

A number of the finest known mirrors and engraved plaques of obsidian are in the Trocadero museum. A square one from Texcoco, measuring 9.5 by 8.5 by 1.2 in. (24 by 21.5 by 3 centimeters), and a round one, convex on one side, from Oaxaca, 6.5 in. (16 centimeters) in diameter, are wonderful pieces of primitive stone-work. The one possessing the greatest archæological interest is the square plaque described by the director, Dr. E. Hamy, on which is the inscription, "*Ypanquetzalitzli* 4 *acatl*" (Dec. 9, 1483, the date of the laying of the first stone of the Great Temple of Mexico). The polished carved figures are exceedingly interesting.

No modern lapidary can do finer work than is shown in some of these old Aztec articles of obsidian. In the City of Mexico, articles are now sometimes offered for sale as antiques which are unquestionably of modern manufacture. These are, in general, crudely carved; and the polish is inferior to that of the ancient pieces. Among such imitations, the writer has observed dozens of masks of black obsidian with gray sheen, 8 in. high, and two figures of small animals, besides other minor articles.

A richly-mottled, red-and-black, brown-and-black, or yellow-and-black variety of obsidian, called marekanite, or "mountain mahogany," is found in the State of Jalisco, often in sufficiently large masses to be useful as a decorative stone, since it admits of high polish. Associated with it in considerable quantity are pearl-stone or sphærulite, which shows reddish-brown spherules in a gray matrix, and pitchstone, a related mineral, which has, however, the luster rather of pitch than of glass. Mineralogically, obsidian is, for the most part, orthoclase, or potash-felspar, while pitch-stone is nearer to oligoclase and albite, containing soda and lime in place of potash.

To sum up the results of this art, we have as the first step of the lapidary process, "flaking," performed upon the wonderful obsidian, producing the flakes used as knives or razors. As the result of subsequent chipping, we have spears and knives, 14 inches in length, which are marvels of careful and patient work. Finally, as polished ornaments, we have labrets, or lip-ornaments; rings, for the nose and ears; ornaments as

well as mirrors that measure 2 ft.; crosses, and other carved objects. The labrets are frequently as thin as paper, and possess a faultless polish. There is in the Mexican National Museum a large figure of a monkey, some 8 in. across, worked out and down to the thinness of paper.

Pyrite (*Iron Pyrites; Iron Bisulphide*).—This mineral also was, to some extent, wrought by the ancient Mexicans into mirrors and other ornamental objects. The mirrors were generally convex on one side and polished flat on the other; and the polish is frequently still retained and very brilliant when cleaned. The convex side was often curiously carved and decorated. There are numbers of these pyrite mirrors in Trocadero (Paris); the U. S. National (Washington); the Field Columbian (Chicago), and other museums, and our ex-president, Mr. John Birkinbine, possesses a very fine one. Among other objects, two are notable: (1) in the U. S. National Museum (Blake collection), a human head, 2 in. high, into which have been inserted eyes of white chalcedony; (2) in the Christy collection, London, two human skulls, encrusted with turquoise, in which the eyes are represented by polished balls of pyrite.

This iron bisulphide, though a very common mineral, is rarely found in masses pure and compact enough to be cut into such objects as those above described. There must have been in Mexico a locality where it so occurred, and perhaps might still be obtained; but the place appears to have been entirely lost. I need hardly say that its rediscovery would be highly interesting to both archæologists and mineralogists.

Tecali, or Mexican Onyx.—This beautiful stone has been for some years past one of the most important mineral products of the Republic. It was carved by the Aztecs into a variety of objects, now to be seen in collections. The name *tecali* is that of its principal locality, and is itself a modification of the Mexican *Teocali*, a temple, literally "house of God," like the Hebrew Beth-el. In 1876, the crude, rough stone commanded $50 per cub. ft. At present the same quantity is sold for, say, one-tenth of that price, or even less. When first introduced into modern art, it was said to come from the vicinity of Puebla; but it is known to occur at several points—Tecali, Tehuacan, Etla, etc.,—in the States of Puebla and Oaxaca, and also in Durango and Coahuila, where it has been more recently found.

The magnificent specimens which surprised the world, when first shown at the U. S. Centennial in 1876, were even finer than those shown at the Paris Exposition of 1900. This Mexican onyx has been an important source of profit to Puebla and Oaxaca, and may become such to Durango and Coahuila, or some of the many other regions in Mexico which contain numerous caves in limestone.

A few years ago, very fine material of this kind was discovered and worked at New Pedrara, in Lower California. The pink variety, here found, which is quite rare, was much admired at the Chicago Columbian Exposition of 1893. But the locality appears not to be worked.

Mineralogically, this Mexican onyx is classed as an aragonite. Dr. Mariano Barcena, of the Mexican Commission to the Philadelphia Centennial of 1876, has published an account of its occurrence and chemical character. It is a carbonate of lime, containing small quantities of the oxides of iron and manganese, to which are due the variegated colors for which the rock is so much admired. The specific gravity, 2.9, shows that it is aragonite. As already remarked, it was extensively used by the ancient Mexicans, specimens of whose handiwork are preserved in our museums in masks, idols, and a variety of other objects. The softness of the material (it can be readily carved with a knife) has tempted some of the modern Mexicans to imitate these ancient objects, in order to meet the demand of tourists; and within the past ten years fully one hundred times as much Mexican onyx has been thus shaped and wrought as was ever used in ancient Mexico. The modern artists often present grotesque, fearful forms, which sell much better than the real antiques or simple copies of them.

This material is entirely stalagmatic in its formation, and carries yellow-brown and red oxides of iron, deposited between layers of the aragonite. It is generally cut across the layers, and thus acquires a beautiful veined appearance. When it is cut, however, parallel with the layers of deposition, a botryoidal structure is well shown, the mineral being so translucent that the colored markings resemble colored clouds. It is one of the most beautiful ornamental stones of any age, and has been used extensively for ornamental purposes in Europe, as well as in the United States, where it was first introduced about 1876. The

natives in the vicinity of Puebla sell a great deal of it in the form of trays, crucifixes, reliquaries, inkstands, penholders, paper-folders, paper-weights, single fruits or bunches of fruit, fish, or other natural objects, which are skillfully carved, not only as to shape, but often with remarkably happy utilization of the colors in the stone. So great is the variety of tints in which the material is found, that there is scarcely a limit to its possibilities for such purposes. Bernardino de Sahagun refers to *iztac chalchihuitl*, white or fine green, and transparent, obtained from quarries in the vicinity of Tecalco, which Dr. Daniel G. Brinton belives to be the modern Tecalco; and the description and locality answer so well to those of our "Mexican onyx," that there can be little doubt that this stone is Sahagun's *iztac chalchihuitl*.

In 1888, Mr. William Cooper, of Esperanza, discovered in the volcano of Zempoatepetl, in southern Mexico, a deposit of a beautiful mineral, to which he gave the trade-name of "mosaic agate," but which is really the same as Mexican onyx, or aragonite—with this difference, however, that while the Mexican onyx is always veined or stratified, the new material is a brecciated or "ruin"-aragonite. The original formation has evidently been entirely broken up, the fragments having been subsequently cemented together, and the crevices all filled with a new deposition of aragonite. In other words, a deposit of Mexican onyx was fractured by some disturbance (probably volcanic), and later deposition of the same material has cemented it into its present form. Like the true *tecali*, it is susceptible of a high polish, the difference between the two being that, in the "mosaic agate," the straight bands of color characterizing the "onyx" aragonite have been broken up and disseminated in fragments throughout the mass, giving an even more pleasing and brilliant appearance. It can easily be cut into thin slabs, makes beautiful ornamental tops for tables and bureaus, and has also been cut into solid columns, and used for the pedestals of busts and statues. For some years past, however, little has been heard of this promising material.

Geologically, the Mexican onyx-deposits are regarded as chiefly of Quaternary age, though those near Tehuacan, at San Antonio de las Salinas, in Puebla, are referred, with probability, to a late date in the Pliocene Tertiary.

Amber.—For 15 or 20 years past, specimens of a remarkable amber have occasionally been brought by travelers from some locality in southern Mexico. The only information gained concerning it is that it is brought to the coast by natives, who say that it occurs in the interior so plentifully as to be used for making fires. It is rich golden-yellow in color, and, viewed in different positions, exhibits a remarkable fluorescence, similar to that of uranine, which it also resembles in color. A specimen, lately belonging to Mr. Martius T. Lynde, but now in the Tiffany collection, Field Columbian Museum, measures 4 by 3 by 2 in., is perfectly transparent, and even more beautiful than the famous so-callel "opalescent" or green amber found in the Sicilian province of Catania. It would be extremely valuable in the arts, if it could be furnished in adequate and regular supply.

Amber was used as an incense by the Aztecs. Fragments have been found on the altars of ancient temples, and also in the Catholic churches in early Mexico. A small flat disk 1.5 in. in diameter, and engraved like the center of the Mexican "Calendar-stone," is in the Field Columbian Museum, Chicago. Like the amber found in the Roman excavations, in Europe, it has a gray or opaque outer coating, on a rich brown interior.

RÉSUMÉ.

The following propositions comprise the conclusions which may be drawn from the foregoing pages, together with statements concerning gems, etc., not discussed, and, in the writer's judgment, not needing to be discussed in this paper:

1. No authentic record is known of the discovery of the diamond in any Mexican State.

2. Sapphire has been found in one instance, as specified on a preceding page.

3. Small emerald specimens, attributed to a locality in Guerrero, are shown at the School of Mines in the City of Mexico.

4. Topaz, in a beautifully crystalline red variety (not yellow topaz, like that of Brazil) has been found at San Luis Potosi and in Durango.

5. Tourmaline has never been found in Mexico.

6. Turquoise is not known to-day as occurring in Mexico; yet, in view of the considerable use of this stone by the Mexicans

of pre-Columbian times, it must be considered as possible, at least, that localities containing it were once known, and may be hereafter re-discovered. Yet it is not impossible that turquoise was obtained by the ancient Mexicans through barter with the peoples to the north of their country.

7. The precious or "noble" opal is found in considerable abundance, but not often of the best quality and highest value as a gem, though, so far as beauty is concerned, the Mexican "fire-opal," with its magnificent profusion and variety of color, rivaling the delicate splendor of the humming-bird, has never been surpassed by the opals from other parts of the world. The disadvantages of the Mexican opals have been sufficiently discussed above.

8. Concerning other minerals already enumerated as used by the ancient Mexicans, such as the other quartz gems, pyrite and obsidian, it may be fairly said that, however interesting to archæologists, they present, at this time, no prospect of value as assets of national wealth or bases of profitable industry.

9. Jadeite, which has been discussed at considerable length in this paper, offers to mineralogists and archæologists a fascinating problem, the solution of which might prove valuable to mining engineers, jewelers, and patriotic political economists also. We are confronted by the startling fact that the museums of the civilized world contain thousands of Mexican objects, wrought with great skill and artistic finish from a material of great durability and beauty, especially when, as is sometimes the case, it possesses a deep green tint scarcely equaled by that of the emerald itself.

What were the original sources of this beautiful and valuable material? Do any considerable deposits of it exist in Mexico? That is not impossible. We may find such a deposit any day. But we must confess that the mauufactured objects known to us indicate no knowledge of the mineral in place to have been possessed by the ancient Mexicans. They seem to have obtained it exclusively from pebbles or boulders in the beds of streams, and never to have followed such stream-beds upwards to a solid original deposit. On the other hand, that does not prove that such a search would not lead modern prospectors to jadite deposits, even equaling those of the famous mines in Burma.

The evidence now at hand from China (where jade has long been a highly-prized art-material) or Burma, where it has been mined with great profit, does not help us much in studying the Mexican problem. One thing seems, however, to have special significance, namely, that neither jadeite nor articles wrought from it have been found so far north as Queretaro, in Mexico, and, so far as now known, have never been found in the neighboring United States. These seem to prove that it was not imported into Mexico; that it was never produced there in sufficient quantities to be exported; that the limited product of it was kept at home for religious or other reasons; and, finally, that the rich deposits of it *in situ*, if such exist in Mexico (as they certainly do in Burma), are probably not far from the districts where it was gathered in pebbles and boulders, to be paid as tribute to conquerors, and to be wrought into objects of religion and art.

From both the scientific and the commercial standpoint, the problem thus presented is not unworthy of attention from members of the American Institute of Mining Engineers.

NOTE BY THE SECRETARY.—Comments or criticisms upon all papers, whether private corrections of typographical or other errors, or communications for publication as "Discussions," or independent papers on the same or a related subject, are earnestly invited.